

IX. *Observations on the Life History of Trichoptilus paludum*, Zell. By T. A. CHAPMAN, M.D.

[Read March 7th, 1906.]

PLATE VII.

THIS species is the smallest and most delicate of our British Plume moths, and also perhaps one of the least common. It has up to the present been remarkable as the only British species of the group, whose early stages were quite unknown.

For the discovery of its early stages we are altogether indebted to Mr. E. R. Bankes, who by reasoning not only scientific, but almost mathematical, arrived at the conclusion that its food-plant must be *Drosera*, although he seemed to fear that this determination would be scouted as absurd.

He supplied me with eggs of the species, and with a first installation of plants of *Drosera*; and from this basis I have succeeded in observing a good deal of its life history, and fully confirming Mr. Bankes' determination of what its food plant must be.

The food plant, *Drosera rotundifolia* (and probably the other forms; I found many larvæ on *rotundifolia*, but the Dorset plants varied somewhat towards *intermedia*), is one that was probably never suspected to support a Lepidopterous larva, and was therefore never searched for that of this species. The prevailing idea is that the plant devours insects, and though this is undoubted, it now appears that to assume that insects would not and could not also eat it, is to fall into a plausible but false method of reasoning. Nevertheless, it comes as somewhat of a surprise to find that a Lepidopterous larva, without any special means of protection, but simply acting in the ordinary larval manner, attacks it with entire impunity. No doubt it avoids walking over, and especially resting upon the gluey glands, but it does this apparently merely because it has no call to do so, and the glands with their secretion are certainly favourite items of its food, especially when it is small.

My observations began in August 1904, when I received

several eggs from Mr. Bankes, laid by females captured at Wareham, Dorset. I find from my notes that a ♀ taken August 20th laid eggs from which two larvæ hatched on August 30th; and from a female captured August 23rd two larvæ hatched on September 6th. A further supply of eggs were received on August 31st. The first larvæ that hatched were placed on all sorts of bog plants obtainable near Reigate, but without result, and when these were finally placed on the *Drosera* plants sent by Mr. Bankes, they were already rather exhausted.

It was on August 31st that the plants of *Drosera* arrived, along with 16 eggs on the same date.

These eggs were loose, two on leno and the rest on a flower-stalk, or rather fruit-head of *Drosera*. Three of the original larvæ survived, and though obviously exhausted, seemed more at home on the *Drosera* than on anything yet tried. One placed on a leaf was, however, in process of digestion next morning. The others had disappeared somewhere, apparently in the heart of the little plants. When the new set of eggs began to hatch after a few days, September 6th, much time was spent in watching the young larvæ on the plants; none were placed amongst the glands on the leaves, but the largest of the unexpanded leaves was selected. They eventually got down towards the centre of the plant and became much more quiet and sluggish there, but still on the move. The next day none of them could be found.

Sept. 14th. Looked at occasionally, nothing could be made of the *Drosera* plants, but to-day a careful examination shows a small pile of frass near the centre in two of the plants. Another shows nothing, and in the fourth is a living larva of *paludum*, a little grown, but out, exposed, and looking sluggish. A curious point is that of the August 30 eggs; those separate, and one on the muslin, hatched, the others on the muslin proved infertile and did not change colour. These hatched September 6th, the eggs on the seed-stem are still (14th) unhatched, they changed colour a day or two later than the others, and their hatching was expected about the 8th, but they make no sign. The young larvæ inside have, since that date, been obviously mature. These ultimately proved to be dead. The eggs remain free from shrinking, mould, or other sign of death or decay, and give the impression of intending hibernation.

Sept. 16th. On one plant a small larva, by the conspicuousness of his darkish tubercles, in its second skin, is seen down amongst the leaf-stems just outside the central heart, covered by a slight web of silk, and this a little obscured by some frass. On another plant a small larva is exposed in about the same situation; this one is well-fed up in first skin.

Remaining eggs are still unhatched.

Sept. 17th. The larva under the web has thickened it both with silk and other material (frass?), so that he is now invisible. On another plant the exposed larva is now quite fat in first skin but is still exposed.

Sept. 22nd. The cocoon is still firm and opaque, its strong structure leads one to suppose it is for hibernation. It is placed between an outer dying leaf-stalk (of a not thriving plant) and the central bud-bulb and the adjacent leaf on its inner side looks as if dying at the tip from being eaten or excavated; this is the only point to suggest that larva is feeding.

The "exposed" larva, though looked for every day, has been invisible since 17th, and it was feared something might have happened to it; to-day, however, it is out crawling over the minute leaves of leaf-bud in centre of plant; no trace is seen (of course without pulling plant to pieces) of where it spent the interval. It is now in 2nd instar. It is about 1.5 mm. long, head dark of about same width as body. I and II are on one large chitinous base, III, IV, and V, smaller. These bases have a slight dark tint, the hairs are long, II nearly as long as width of body, I perhaps $\frac{1}{4}$ of II, III long, IV and V each rather shorter. The larva might be described as pale whitish-fuscon with a reddish dorsal line and another between II and III, but it seems more accurate to say the ground-colour is pale reddish-brown, and that there is a narrow white line round each large tubercular plate. The larva being young, in this instance I and II reach practically from front to back of segment, leaving only room for the narrow pale line. The hairs are very distinctly thickened at the tips.

Sept. 24th. A plant on which a larva was placed, September 6th, and of which no trace could since be found although the plant has been examined most carefully nearly every day, when examined to-day was found to have on it a larva in second skin which was constructing a silken web over itself, at the side of the central bud and

close to the base of a larger leaf. No trace of any of the work of the larva in the interval can be found.

The larva found on 17th has thickened its web and pellets of frass are conspicuous on its upper surface. The larva can still be faintly outlined beneath. The first larva is quite invisible.

Oct. 22nd. The three inhabited plants are not looking flourishing; two which have the largest green centres have the cocoons as last described, the third, however, has only a small central bit of green, and there is a new and larger cocoon on the other side of this from the original one, that does not look much different; the new cocoon is still imperfect, and one glimpse was got through it of the black head of the larva moving about and apparently spinning, and again of the body of the larva, of which no details appeared, but it was decidedly larger and of a flesh tint. It is unfortunate that the larva was not seen when on the move and transferred to a better plant and a description of it taken. The presumption is that it is now in its third skin,

Oct. 24th. This larva is found crawling about outside to-day, it is a question whether it is not merely in second stage; it is just fully 2 mm. long, head black, general colour flesh-colour, made up of white and reddish markings. The tubercles I and II are united on one base, II the longest hair, and has one secondary hair behind it, one or two tubercles seem to have another secondary hair. No other secondary hairs to be found. Base of hairs and spiracles dark, first thoracic plate has a white central line with black line on each side and a black spot further out.

Each tubercle is surrounded by a white area, between is dull red; the red area has fine skin points which are absent or very indistinct in the white areas. Hairs slightly clubbed, III bent forwards, front upper of IV + V directed rather forwards, shorter than the posterior, which is directed outwards.

The white and red is perhaps better described as in longitudinal lines, a red dorsal one, then a broad white, including I and II, then a red one which has various processes, so that the description of white circles round tubercles results from these taking circular arcs, with tubercles, spiracles, etc., for centres. But there are other centres with white that are not at present occupied by tubercles. On first segment is a little longitudinal stripe

of red from I forwards, and on the thorax the dorsal and next red line are more or less conjoined.

Under low magnification the thoracic plate looks nearly black and somewhat homogeneous in colour.

Inside I and II is a dark depressed spot. Anal plate not dark.

The larva is not tormented to get a fuller description, but is carefully placed on a better plant in hopes of rearing it.

Oct. 27th. The larva was found (25th) to have made some slight spinning. Yesterday (26th) the spinning was a fairly complete cocoon with some black dots of frass, and to-day it is more dense and the larva is completely hidden.

Nov. 20th. Larva (No. 2) noted 27th remains *in statu quo*. Another (No. 1) is found to-day to have begun a new tent; it is still somewhat visible through the silk, and can be seen to be fat and larger if anything than No. 2 at its spinning, but no details are discernible. No. 3 has its cocoon wet from water soaking up the plant; on this plant the centre bud is wet as it is not in plants of 1 and 2. The cocoon does not look very satisfactory, and possibly the larva inside is not doing well.

Dec. 10th. No. 2 (of Nov. 20th) is found to-day outside its tent on the move, and opportunity taken to describe it. It does not seem to have grown or to be in feeding humour—moves very sluggishly—is thick and short, is yellow with very large porcellaneous-white plates or perhaps is rather porcellaneous-white with certain yellow or orange-ochreous lines. The plates being apparently surroundings of tubercles, the tubercles and hairs are black, so that the little larva is a rather striking object when closely examined.

Length when stretched 2·7 mm. Taking the white as the ground-colour, there is a narrow dorsal orange line, a little widened in front of each segment and sending branches, pale and less conspicuous, along the front and back margins of segment, so that they are lost in the incisions when the larva is not stretched. I and II are close together, and on a common eminence, and almost conjoined. These and other tubercles single-haired. Between I and II and III is another longitudinal ochreous line. Round I and II the surface is smooth and porcellaneous, but in front of segment on each side of dorsum is an area with five skin points. Head and spiracles black. The

subdorsal yellow line (between I, II, and III) sends down branches marking off a somewhat square white area round III; III placed slightly backward, IV + V, first one highest with shorter hair. Hairs about half the diameter of larva in length. Props of prolegs rather short.

When at rest the incisions are deep and the segments stand out high and cushiony with the elevation of the tubercles—especially I and II, and IV and V—making angular points.

Below IV and V is a single hair and at base of prolegs the usual three hairs, which are however very conspicuous, being black in a white ground. On 1st thoracic the plate is rather dark, divided centrally by a pale, hardly yellow line, with, on either half, a nearly central large hair, a small one at outer angle and three along front edge, a three-haired tubercle in front of spiracle and one at base of leg.

Second and 3rd thoracic has on either side four double tubercles along middle of segment, the third with an extra hair above and behind it and the prolegs carry 7 crotchets in a circle, incomplete at its outer margin. The black crotchets on the pale white base have a very pronounced aspect different from the more usual pale brownish crotchets on a yellowish base.

1905. Jany. 14th. Not liking the look of my plants I examined them. The first was dead, remains of a larval head detected. No. 2 was alive, but no trace of larva could be found. The third contained a larva, which was preserved, lest worse befall him. He seemed much as described at last entry. The cavity containing his cocoon was excavated towards the heart of the button, or bud of the plant, several of the small undeveloped leaves (?) being well eaten into. This bud preserved *in formalin*. When the cocoon was removed, the eaten portion, or rather what was not eaten, formed a small hollow into which, or *on* to which the cocoon would just fit.

This closed the campaign with the 1904 eggs. It appeared from this that the young larva feeds somewhere in the centre of the plant as an internal feeder, and finally makes a cocoon in the heart of the plant for hibernation. The one cocoon of which I made the most satisfactory examination, consisted of a cavity the greater part of which was excavated out of the material of the outer leaves of the centre bud (winter bulb) and completed by a silken

cover. This renders it certain that some of the central material of the plant is eaten; but for this, my experience in 1905 would have led me to suspect that the young larvæ fed on the leaves as those of the summer brood do. The larvæ in their first instar on the leaves are often very difficult to see and find, even when one is sure they are there, so that in my ignorance in 1904 I might easily have overlooked them. I am still inclined to suspect that it is possible that in the first instar they feed on the leaves in the same way as the summer brood do, and only descend to the centre of the plant in the second instar. Against this is the fact that the young larvæ directed their wanderings to the centre of the plant, and that the centre was found to have afforded a good deal of food material. The note in describing one larvæ, as to the presence of secondary hairs (October 22nd), and the surmise that it was in third instar, agrees with later observations; it is probable that this larva was endeavouring to complete its cycle without hibernating, and really was in third instar, as second instar larva do not show any secondary hairs. This larva probably perished earlier than the others.

So the matter remained for further investigation in 1905. The larva, like so many of the Platyptiliid division of the Plumes clearly hibernated full-grown in its second instar, and ought to be discoverable in the spring in its further stages. I owe it to Mr. R. South that I was able to visit a locality for the species, and to continue the observations in 1905. Of course I did not quite know what to look for, but, as good luck would have it, the discovery of the larva in the spring proved fairly easy.

1905. May 31st. Accompanied Mr. South to a locality in the Esher district of Surrey, where *Drosera* is found, and where *T. paludum* had been taken, and searched for larva of *T. paludum* and found about a score.

The first specimen was found seated on the under-side of the petiole of a leaf of *Drosera*. It was nearly full-grown, and was of about the length of the petiole. This will give some idea of the size and state of the plants, which were growing on peaty ground amongst heath and apart from *Sphagnum*; most of them were very small with the leaves lying flat to the ground, the one above noted being a fine specimen about twice the size of the majority. There had been a drought for a considerable period before this, and the ground was by no means boggy. The small size was

more probably due to drought than to the period of the season. A fine plant would be 35 mm. across only, a majority 25-30, and some only 20, and even less.

The remaining larvæ were found in various positions, some on the petiole, some under and some on top of the leaves, and some sitting across the centre of the little plant. In no case, either in the field or in various observations afterwards at home, did a larva place himself on the top of a sound healthy leaf. They seemed on the whole, however, to be rather reckless in the way they moved about amongst them. Their hairs probably protect them against contact with the leaf-glands unless they actually walk over them. They would eat any part of the plant, least frequently, however, attacking the central bud. The most usual point of attack was the margin of a leaf, approached by the larva seated on the petiole or beneath the leaf, and in several cases the attack was continued till the whole leaf was eaten and a portion of the petiole also. In one or two cases the larva attacked and ate the glandular processes, until it had cleared the middle of a leaf which then formed its resting-place. Twice a larva, looking for a place to pupate, escaped from a flower-pot by crossing the water in the saucer, so that they are probably able to deal with the habitat being flooded without much injury.

The larva is a brownish-red above, varying from rather dark to a bright rosy colour, and sometimes with some greenish shades; beneath, it is green. The dorsal tubercles are darker and more rosy, and retain a bright rose colour when the rest of the larva when fixed for pupation becomes quite green; the colour involves not only the tubercles but a little of the base around them, especially behind. The hairs are long and slightly clubbed or rather flattened at the end, and so the ends reflect light so as to look larger than they actually are. The resulting appearance of the larva is that it looks very much like some aspects of the *Drosera* leaf; sometimes the hairs, sometimes the red tubercles suggesting the glands and their supports on the *Drosera* leaves, and the general tone of colour is much that of the green leaf seen through the forest of rosy hairs. In looking for a larva a slightly edgeway view of a leaf often suggests a larva, and a larva is probably easily overlooked by its close assimilation to the plant.

The larva taken were for the most part in their last skins, and their measure was 7 mm., and a large or well-

stretched one 8 mm. long. Several were, however, in the previous skin, and one so small that I took it to be in the antepenultimate. This was clearly erroneous.

The following day, June 1st, several fixed themselves for pupation, one on the under-side of a *Drosera* leaf, another on a thread of heath-stem.

June 2nd. Several more fixed themselves up.

„ „ 1 pupated this afternoon.

„ 3rd. 7 a.m., two are now in pupa.

The rapidity of their finishing feeding is apparently great. The temperature of the last day or two has been about 70°.

June 15th. The last larva has pupated.

„ 18th. 1 moth emerged this morning and one in the afternoon.

„ 19th. 3 emerged about 10 to 11 a.m.

„ 21st. Two more moths emerged yesterday.

These seven moths have all been confined over a pot of food plant as they emerged. Yesterday one was found entangled in a fold of the muslin cover, this is probably the same one that is found dead this morning with one hind-leg missing. Another is found attached by the *Drosera* gum to a leaf by the tip of one leg. Two eggs are also detected, one beneath a petiole, and the other attached to a gland-stalk at the margin of a leaf.

June 29th. The last moth emerged to-day.

Mr. South notes on July 15th that all four of his *paludum* pupæ emerged. Two paired, and the female was kept alive and laid eggs by the 19th on and around the food plant; it was from some of these ova, as well as from some laid by my own moths, that I was able to rear examples of the summer brood.

He also gives me a note on the emergence of the moth from the pupa, as follows: "July 25th. Watched an imago of *paludum* emerge about 12 o'clock (noon). When first seen, about half the insect was free from the pupa, which was attached to the side of a tumbler; it then remained perfectly still, except for a slight gliding forward motion which continued for about three minutes, by which time only three segments remained in the pupal case, then all movement ceased for a few seconds, when, with a sudden jerk, the insect shot forward and downward alighting on the glass about two inches from the pupa. All the time it was under observation, the antennæ and first pair of legs were free but perfectly still."

This describes very well the habit of this and some other Plumes I have observed, of resting during emergence, and for a good deal of wing expansion to take place during the process, so that it almost looks as if the wing was extended by the process of drawing it out of the pupa-case.

June 26-28. Eight larvæ hatched from eggs received from Mr. South, and were placed each on a plant of *Drosera*, on petioles low down, in the belief they wanted to go to the central bud.

June 29th. Four of these larvæ are now easily seen in the centre of a leaf leisurely eating the very short stemmed hairs and glands that occupy that position; one has already cleared a little circle of more than his whole length in diameter. The intestinal contents look dark. One concludes that those eggs are most naturally placed that are on the stem of the glands at the margin of a leaf.

One observes also that the *Drosera* is infested by an *Aphis*. This is of interest as bearing on the supposed immunity of the plant from insect attack due to its insectivorous habit. Such immunity would appear to be a fiction.

July 2nd. These larvæ clear the centre of the leaf of the short stems and glands that occur in that position, leaving the longer marginal ones alone; the little larva itself, even when grown a little, is very inconspicuous and difficult to find. With a lens, the cleared central portion of the leaf, with red frass scattered over it, is easily seen; but without a lens, the red frass gives very nearly the same tone to the leaf as the glands do, so that except by very close scrutiny nothing unusual presents itself.

July 2nd. This morning one larva is found to have changed its skin, and appears to be eating the cast skin. The moult occurred near the centre of the leaf, where the feeding was done; the only protection by way of web, tent, or any other shelter, is a few threads spun across the tops of the adjacent glands, making a flimsy and almost invisible cover. The larva has a relatively rather large head, and the hairs are about as long as the larva is thick and look dense and crowded together. The larva is still pale and transparent looking, but the eye-patch is densely black, the dorsal tubercles (not the hairs) are dark, and the dorsum has a pale ruddy tint; the longer hairs are slightly clubbed at their tips.

In the first skin the larva grows a good deal but remains

very colourless or rather transparent, the dark intestinal contents being conspicuous, and the only coloration being a denser white round the bases of the dorsal tubercles.

July 3rd. Two larvæ (of the eight that hatched from Mr. South's eggs) that had gone a-missing are now seen to have hidden themselves, and still are, in unopened leaves, amongst the undeveloped glandular hairs, with which their interiors are full. The leaves are now slightly opened and frass is very evident. These larvæ, therefore, went into incompletely expanded leaves in order to eat the glands; these were not, however, probably functionally active at this stage. The smallest larva found was just about to moult for the last time but one; its general aspect was precisely that of the larger larvæ and the disposition of the primary hairs is identical though they are not so long; there are no secondary hairs, however, to be discovered. The length is 4.5 mm., the longest hairs are about 0.5 mm.

The next smallest larva was about to moult for the last time, its length was about 6.0 mm. The longest hairs about 0.8 mm., and there are a good many secondary hairs, two or three round I and II, one behind III and one above and behind IV and V. These are secondary tubercular hairs not skin hairs, as are also those of the larva in its last skin.

The full-grown larva is 7 to 8 mm. long, of a form much like *rhododactylus* or *zophodactylus*, thickest about third or fourth abdominal segment, and tapering to either end, but when at rest or feeding has the forward segments rather contracted, so that it looks thickest about the metathorax, and the mesothorax seems nearly as large; in colour the dorsum is red or reddish-brown or pink, with an underlying green tone, the difference of tint being due rather to the attitude of the larva, and the degree to which it is fed up, rather than to individual variation. The hairs are very long and many of them are clubbed, being somewhat flattened at the tips especially; some are dark with white tips which look club-like. The hairs transmit and reflect the red of the larva and of the hair-glands of the plant, so that the resemblance of the larva, in some aspects, to a leaf is very close; in others a leaf seen edgewise may be easily mistaken for the larva one is in search of. This is assisted by the lower surface of the larva being green, separated from the upper red surface by a yellow line, sometimes not very conspicuous in tint, but in some

very bright; it occupies the lateral prominence (upper portion of lateral flange) which carries tubercles V and IV. Below this is a second flange-like projection carrying VI (a single hair directed forwards), which is marked off above and below by a rather deep sulcus, and which bends downwards in front, upwards behind. There are two paler dorsal lines just within the dorsal tubercles, rather curved outwards at the middle of each segment; the space between them is a rather greener pink than the rest of the dorsum, due to the dorsal vessel showing somewhat. There are other pale marblings, especially a tendency to a line through I and II. This, however, is much interfered with by the large size of the combined base of these tubercles, almost entitled to be called a hump, which is of a dark dense red that extends a little beyond, especially behind, the hump. This red, which at that stage becomes a brighter pink, persists when the larva is laid up for pupation, when all the rest of the larva has become green. The lateral yellow line is abdominal only, the same region of the thorax is pink. There is a pale (yellow) spot in front of III, and below there is a pink shade in the green (yellow?) under-surface, above, behind, and below VI, which stands out on a yellow eminence, as does also the eminence of the three hairs at base of prolegs. The larva at rest is about 1.1 mm. thick, whilst the dorsal hairs (II) are about 1.6 mm. long, legs nearly colourless, prolegs pale (colourless), tall, slender, with a bulbous end, hooks wanting on outer aspect 7 to 8 in number, 9 on claspers.

With regard to four larvæ taken by Mr. South on May 31st he remarks that one was suspended when he found it "head downwards from its anal attachment to a slender twig of heather. Another was on the middle of the crown of its food-plant; neither of them changed its position, but are now pupæ in the exact places they occupied as larvæ when I came across them. A third larva had pupated on a heather twig, and the fourth had pupated on the flat rim of a fern pan in which I set the food plants. A curious fact in connection with this last larva is that although I had twice removed it from the rim of the pan, it succeeded in getting its own way, and became a pupa on the spot it had fixed upon, and there it now remains."

July 8th. A small larva (very young in second skin) had wandered off in the test tube in which I had put it for observation and was probably hungry. I put him on

the petiole near the base of a vigorous leaf on which the red glands had each a large globule of gum. He walked very deliberately to the base of the leaf (upper side), apparently spinning a web, and also searching carefully from side to side. At length he arrived at the gland hairs which next the petiole are deflexed down it; these he carefully examined on each side of his way even moving quite to the side of his proper track, his method looked as if he contemplated climbing up them. The largest are about three times his length (2 mm.), but actually when he reached as far as he could without removing more than one pair of prolegs from the leaf, he withdrew and continued his march. At length he got nearer the middle of the leaf, and found that his reaching-up process brought him to the glandular top of the hair. This (the red knob and transparent gum) is thicker than, and in bulk nearly one-third that of the larva. I watched him demolish one of these, which he did rather quickly, and make considerable inroads on another. The gum, which is thick and glairy and draws out into threads, was eaten; he got his legs into it, and ate the stuff off his legs and also ate up the portion drawn out between them; he did not, however, appear to completely clean his legs, yet shortly after they were certainly quite clean and the gum was removed; though he worked at one side only, it disappeared also from the other. Possibly the elasticity of the gluey stuff pulled it off, but I was certainly puzzled to know how several legs got quite clean in some mysterious way. He ate up the red knob of a size about equal to his own head. He left the green gland stem. In attacking the second gland, he appeared to get the front of his head into the gum, and drew it out showing the front of his head and his legs to be involved in it. He ate away, however, quite unconcernedly, and though again I saw no definite cleaning process, he was apparently quite clean immediately afterwards. The gum stuck to his head and legs in such a way as to make it difficult to suppose they got clean because it did *not* stick to them, nor did it appear to be wiped off against the plant. Up to full growth in the second skin the food of the larva seems to be entirely the red glands and their secretion.

July 14th. Visited *T. paludum* in its habitat, and observed three larvæ, two laid up for second moult and one for a third.

Moths that were confined over growing *Dioscorea* with a view to eggs never got caught by the plants, except on one occasion when a moth escaped only by losing a leg caught in the glue; another moth fell on a leaf, where it died, and, being left there, was largely enveloped by the leaf after a few days.

July 16th. The larvæ fed up in confinement have been paler than the captured ones of the first brood, and also than those taken two days ago. These pale larvæ are green, with no red except on the dorsal tubercle as in the ordinary newly changed pupa, and a pupa is without any trace of red whatever. These green larvæ show very well the greenish-yellow subdorsal lines (just dorsal to the tubercles I and II) and also the slightly oblique one below them.

The larvæ when small were given to wandering, if the plant was not strong and healthy enough to surround the red glands with plenty of fluid gum, these glands and the gum being their favourite (and only) food, unlike the winter brood which eats the central portion of the plant. Later the larvæ would eat anything, being fond of the flower-bud and flower-stems, and eating nearly the whole of the leaf. When nearly full-fed, if the plant was a small one and the leaves well demolished, the larvæ would eat portions of the petioles and finish by clearing off the spring leaves and central bud of the plant. One or two young larvæ appear to jerk the frass away, but as a rule the frass remains where excreted. The young larvæ thus leave minute red dots more or less in rows or groups, in some degree replacing the devoured glands in the colour scheme of the leaf. In its later stage a larva would sometimes eat a large quantity without moving; this especially happens when it takes to the middle of the plant and can reach much food without moving, a pile of green-black frass about twice as bulky as the larva accumulating in some instances. All being well with the food plant, the larva has no tendency to move until the time for pupation arrives.

EGG.

The egg is laid (in confinement) on the petioles of the glands near the margin of the leaves; this was sufficiently frequent to suggest it as the situation preferred. They were also laid on the

under sides of the leaves, on the petioles and on the dead flower-stalks of the previous year, and even on the peat beside the plant. It is bright yellow at first, becoming afterwards duller in tint. It is oval in any longitudinal section, circular in any transverse one. Its length is 0.38 mm. and its diameter 0.24 mm.

It has very large bold sculpturing consisting of a net-work of ribs enclosing irregular polygons. The ribs are broad, about one-third of the width of the enclosed hexagons (or as may be). The diameter of the cells is about 0.02 mm., of a cell and one wall about 0.026 mm.

NEWLY-HATCHED LARVA.

The newly-hatched larva is fully 1 mm. in length when stretched out. Head, prothorax, and anal plate dark, but not black, hairs and bases dark, the rest white or colourless. Tubercles I and II are distinct from each other but very close together, I very small, hair about one-sixth the length of that of II which is about 0.06 mm. long, both incline backwards. The corresponding hairs on 2nd and 3rd thoracic and 9th and 10th abdominal segments are no less than 0.20, 0.23, 0.40, and 0.20 mm. long respectively, that on 9th abdominal segment being in fact as long as half the length of the larva, when it is not extended. III is about 0.17 mm. long and is directed forwards. IV and V are on distinct bases but very close together, rather more on a level than usual (the contrary, for example, of *Amb. acanthodactyla*), front hair 0.06 mm., posterior 0.18 mm. long. A long way below, about middle of segment, are two hairs, one about 0.17 mm. long and the other below and in front of it about 0.1 mm. VI appears to be absent and these are two of the three hairs of VII. On the prothoracic plate one of the three usual front hairs seems to be absent, and only the long central one of back row is clearly seen. Of the usual four pairs of hairs on meso- and meta-thorax, the third appears to be represented by one hair only.

The props of prolegs are about 0.04 mm. long, with three crotchets, four on claspers.

The larva appears to have 4 instars. In the first it is without tubercle VI, and without skin points. In the second instar it acquires these, and I and II acquire a common chitinous base. There are no secondary hairs. At this stage it hibernates in the autumnal brood.

In the third instar it acquires a small number of secondary tubercular hairs, making the tubercles into warts.

In the fourth instar it differs from the third in the

secondary hairs being more numerous, but there do not appear to be any secondary hairs on the general skin surface, VI remains a solitary hair, and there is no indication of secondary tubercles either on the thorax, or behind the spiracles on the abdomen, I and II form one compound wart, though the two primary hairs are quite distinct. The prolegs have 6 and 7 crotchets.

DESCRIPTION OF LARVA OF *T. paludum* FROM SUMMER BROOD.—July 7th.

First Instar.—Rather over 1 mm. long, whitey-green, almost transparent. Head black, thoracic plate dark, as well as scutes of tubercles and anal plate. Each tubercle has a distinct plate, larger than the mere hair base. I and II are on a common base, as are also IV and V, the hairs are black. The thoracic plate has three hairs of same length in front, central of back series very long, other two short. Single hair in front of spiracle. On second and third thoracic segment are the usual four pairs of tubercles on each side, each pair on a single plate and third pair apparently possesses a third hair on the same plate. The head has a very long hair on the centre of each side of the front of the cranium. The long hairs on head and 1st and 2nd thoracic segments about 0.13; hairs II, III, and IV on abdominal segments about 0.1. Points of hairs white and apparently clubbed, towards moult shows some reddish tinting between the tubercles.

Second Instar.—2 mm. long; hairs white, arising from black points, more clubbed and proportionately shorter than in first skin. No secondary hairs. The tubercles are on distinct largish plates of a faint cinereous tint, and round them is a whitish shade as of a porcellaneous-white thickening of the skin. The rest is a pale brownish-red, forming a dorsal band, a line along the posterior border of each segment giving a branch forwards (and obliquely upwards) between II and III and between III and spiracle. There is however some variation in tint and extent of red marking, either in different specimens or according to different degrees of maturity. The central hair on head is still long. The first and third posterior hairs of thoracic plate are very short compared with the long second one, the outer one of front row is also long. The prothoracic plate is paler, with dark marbling on each side of central suture, and the dark spot between 2nd and 3rd hairs is distinct, rather nearer posterior margin of plate. The perspiracular tubercle has three

hairs. Anal plate carries six hairs on either side, the spiracles are black but not very large or prominent.

Third Instar.—3.5 mm. long before feeding much; it has now quite the adult "plumage," though the secondary hairs are fewer and much smaller than in last instar. The tubercles are on or rather form almost raised humps. The secondary hairs are four on I and II, two or three of them very small and inconspicuous, one on III, none on IV and V or on VI. These secondary hairs are white and clubbed. The primaries arise from black points, are ochreous, with white clubbed tips. The skin points, wanting in 1st instar, transparent and sparse in 2nd, are now abundant. The tubercular areas are free from them; these areas, which probably correspond to the earlier tinted scutes which are not present now, have a little differentiation of colour and texture to mark them off from the surrounding skin. The larva is still very transparent and flimsy looking. The white under the tubercles seems subcutaneous, as does also the red-brown of the dorsal stripe and of a great part of the rest of the larva. The red is however in marks or marblings, but not in continuous streaks. Two hairs on head and on meso-thorax are long but only little longer than the longer ones on the abdomen. The longer hairs are from 0.35 to 0.4 mm. long, not, some three times as long as others, as in previous instar. The prolegs are long props, slightly bulbed at end and with seven dark crotchets round the inner margin. The six eyespots are very prominent, more than hemispheres. The head is translucent with ochreous marblings. A large black mark under eyespots, but three of them escape it, or seem to do at certain angles and look quite white.

There is a short hair ventrally close to middle line in abdominal segment without prolegs, probably present in other instars though not noted. The last joint of the true legs is markedly long and slender.

These detailed notes on the progress of individual larva were much broken up and rendered of little use by the way in which the larva succeeded in hiding themselves, as well as cases of wandering away to another plant, really getting lost, etc. This occurred with larvæ each on a separate plant. In several cases, I gave up the larva for lost, but it duly reappeared again. These facts apply most to the youngest larvæ, and are the ground for my suspicion that in the autumnal larvæ I may have been wrong in thinking they all fed only in the centre of the plant, though the extrusion of frass there, in one instance observed, could only be compatible with the larva being

ensconced amongst the leaf-buds of the central rosette. These notes refer frequently to the young larvæ (1st and 2nd instars) eating especially the glands, the leaves themselves being attacked only by the older ones (3rd and 4th instars). It is also noted that the larvæ eat their cast skins. As to one larva it is noted as very green and yellow, with no red except the dorsal tubercles, and that it was on a rather pale plant of *Drosera* surrounded by plenty of *Sphagnum*. And the identity of their schemes of colour with that of the plants or leaves they were on, is several times referred to.

PUPA OF *T. paludum*.

The larva seeks for pupation a bit of slender upright stem, the ideal position possibly being the dead stem of last year flowers; a slender bit of heath will serve, one of mine pupated on the under-side of a leaf of *Drosera*, and Mr. South met with one that pupated across the centre of the food-plant. But a bit of dead grass-like stem is what the larva prefers; no fewer than three selected the only piece of this material in one of my tins, and a fourth fixed itself at its base, being crowded off by the previous tenants. Of six in this tin, the two others selected slender stems of heath. The larva will take a horizontal position and does not much mind which side it is up, but appears to prefer one with dorsum upwards. When it obtains its pupal position on a vertical stem, it always fixes itself head downwards.

The change before pupation in the larval colour is very marked, the whole larva becoming green except the hump of I and II, which assumes a conspicuous dark rosy-pink. For some time after pupation the pupa has the same coloration, the pink eminence being very conspicuous and ornamental in the green pupa; gradually however the colours change, the pink fades and the rest of the pupa, remaining green, acquires an overshadowing of faint ruddy brown, disposed, roughly speaking, in longitudinal bands; in one of these the tubercles I and II still present a slightly darker shade but in only one or two cases at all decidedly so.

The length of the pupa is 6·7 mm. width, thorax 1·3, abdomen 1·2, 1 mm. about 5th abdominal, the ♀ apparently a little shorter and thicker. The thickness is much the same to nearly the end of 5th abdominal segment (and wing cases), whence it (in 2 mm.) tapers regularly to a rather fine point, at least it does as seen sideways, and, seen dorsally the thorax is wider than the following segments and th

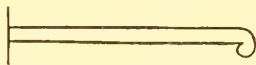
tapering of 6th abdominal onwards is by a curved outline with sharper finish in 9th and 10th segments. The head in front is rounded but has two lateral and a double (or two minute) frontal eminences between them. Seen dorsally when the form has been fully acquired, but the pink colour of the dorsal tubercles persists, it is a most beautiful object from the elegance of its outline and delicate but bright colouring. The hairs are of some assistance to the pleasing effect. Before describing the hairs, it may be best to note that there is the usual double dorsal flange or ridge beginning behind middle of mesothorax with a rounded eminence succeeded by a lower one, then running across metathorax and abdominal segments in line of tubercles and ending with tubercles on 3rd abdominal segment. It is not high and marked as it is in some plume pupæ, but is quite definite and distinct, the tubercles on the following abdominal segments (4th, etc.) are in line with it but represented only in the middle of each segment, there being no continuous ridge between them.

The hairs on the mesothorax are, on either side, two in line of the dorsal ridge but in front of it, and about the distance apart that the last one is from the initial hump on the ridge, outside each of these, is again another hair, all equally spaced, so that there are two rows of four hairs across mesothorax in front of anterior end of ridge. The prothorax has a row of six hairs across it, three on either side. One or two of the head (antenna-basal?) hairs come into this same dorsal view. These hairs are all colourless and about 0.7 or 0.8 mm. long (two-thirds thickness of pupa). On the head are, in front above, two hairs on each side and one on each side below, above the labrum. These are 0.3-0.4 mm. long, colourless. On the metathorax are two hairs, one on either side, white, about 0.6 mm. long, porrected and arising at front margin of segment from the ridge. They appear to correspond with the first of the two hairs in the following abdominal segments which have the same appearance, nearly the same length and direction (porrected) but arise further back on the segment. The metathorax has no posterior hair as the other segments have. 1st, 2nd, 3rd, and 4th abdominal segments have each two hairs on either side, apparently I and II, not arising very close together but still on a common eminence which on 1st, 2nd, and 3rd is part of the dorsal ridge, the hairs are at an angle to each other of about 90°, the first directed forward, the latter backwards and increasing the angle by a little curvature, the posterior one is black, quite 0.6 mm. long, whilst the front one is shorter on each segment, up to the 4th abdominal. On the 5th and beyond there is only the posterior one, on to the 9th segment, when it is at posterior margin of segment. It has about the same length (0.6 mm.) on each segment. On these segments is

a little eminence and scar suggesting where the missing I would have been. On the front outer angle of metathorax are two minute black dots. On the first abdominal segment at same place, is a similar dot with a large spiracle-like oval scar behind it and of a dark colour. Otherwise there are no hairs or other structures, except the small ochreous spiracles down to the subspiracular flange, on this are two minute black dots (IV and V) on 3rd to 7th segments, on 8th are at the same places two short (0.3 mm.) hairs. These are repeated on 9, except that the 1st has another just below it. On 10th one similar hair seems distinct from cremaster hairs to which it is very close and equally short but straight. The double dots that occur on 3rd abdominal to 7th are forwards rather close together and behind the spiracle. More ventral on 5th, 6th and 7th abdominal segments, in fact ventral, are on either side two short deflexed hairs (VII) about 0.1 and 0.2 mm. long; on a pale line between these and the subspiracular flange is a small black dot, hardly a hair (VI). A similar trace of III is also to be detected. On the several lines of these, viz. III, IV + V, VI and + VII, there are longitudinal pale lines, that look sometimes like ridges, largely owing however to coloration, but this is just so much raised on the subspiracular (IV and V) one that I have ventured to call it "subsp. flange."

The appendages reach to the middle and even to the posterior margin (in ♂ s?) of 5th abdominal and look attached to them but are free beyond 3rd.

The cremaster consists of two portions, a small one in centre of 9th and a larger one on 10th. The hairs, together with the dorsum of the last two segments, are pinkish about 0.1 mm. long, straight or nearly so with a small knob at one side of the end, as though a hook had soldered itself to the shaft where it had turned round to.



The appendages are transparent green, with rather darker olive shading, beside the wing veins, on antennæ, and first leg.

The variation in the colour of the pupa is first in the amount of pink. This tends to fade as the pupa matures, and some pupæ lose it altogether, becoming entirely green. One pupa, on the other hand, has a dorsal, a broad subdorsal (through hump and hair bases), and a lower (along III ?) rose-pink line nearly continuous from end to end of the pupa, and is consequently a handsome, brilliant pupa. The depth of green also varies a little, especially on the

wings and appendages which may be pale and transparent, or a deep solid-looking green. A certain olive-brown tint appears as the pupa matures for emergence, the eyes, wings, etc., becoming black.

One other point in the variability of the pupa has regard to the forward hairs (I) of the abdominal dorsum. The most usual form is perhaps that described with this hair on the first five segments, and wanting in the others; it does not often show any length on 5th segment, and is more frequently wanting on 4th, 3rd, or even 2nd, and presumably may be entirely absent. When absent it is, however, usually represented by more or less of a stump or abbreviated hair, and its site when absent is marked by a basal circle or point. It is unusual, however, as happened in the specimen described for the hairs present to be well developed and the rest to be absent, *i.e.* merely a basal trace present. It is more usual for there to be one or two intermediate abbreviated hairs, as, for example, 1st and 2nd good hairs, 3rd shortened hair, 4th very short, 5th stump, 6th wanting or some such formula.

EXPLANATION OF PLATE VII.

-
- FIG. 1. Egg magnified $\times 56$.
 2. Larva 1st Instar $\times 30$.
 3. „ 2nd „ $\times 20$.
 4. „ 3rd „ $\times 14$.
 5. „ 4th and last Instar side view, $\times 8\frac{1}{2}$.
 6. „ „ „ semidorsal view, $\times 8\frac{1}{2}$.
 7 and 8. Pupa. Lateral and dorsal views, $\times 8\frac{1}{2}$.
 9. Larva in 2nd Instar in centre of leaf. In the figure the conspicuousness of the larva is much exaggerated. Correctly represented it would hardly be visible. $\times 4$.
 10. Last stage larva feeding.
 11. Portion of leaf as eaten by larva.

In Fig. 2, except a dorsal hair or two, the setae shown are only those of the one side. I and II together, III spiracle not shown, IV and V together, VI wanting, two hairs of VII.

In Fig. 3, the tubercles I and II of both sides are shown, VI present, VII hardly visible being beneath, spiracles hardly indicated.

In Figs. 4 and 5, dorsal tubercles of other side, only indicated by a hair or two.

Fig. 9, almost impossible to show satisfactorily.

MAY 29, 1906.